MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023 (TERM ID 2220)

FETM4166 – RADIO NETWORK PLANNING TOWARDS 5G

(Free Elective)

11 JULY 2023

9:00 A.M – 11:00 A.M.

(2 Hours)

INSTRUCTIONS TO STUDENT:

1. This exam paper consists of **7 pages** (including cover page) with **3 questions.**
2. Attempt **ALL questions.** The breakdown of marks within each question is given.
3. Please write all your answers in the answer booklet provided. Show all relevant steps to obtain maximum marks

Question 1

The following table gives the configuration for a WCDMA (3G) cell:

	Notation	Unit	Downlink
Target load	l	%	80
User bit rate	R	kbps	144
Carrier frequency	f_c	MHz	1800
Transmitter			
Max. power per connection	P_t	Watt	5
TX antenna gain	G_t	dBi	13
TX cable loss	L_t	dB	3
TX antenna height	h_b	m	30
Receiver			
Receiver noise figure	F	dB	6
Required E_b/N_0	E_b/N_0	dB	7
RX antenna gain	G_r	dBi	1
Antenna diversity gain	G_d	dB	2
Soft handover gain	G_{ho}	dB	1
RX antenna height	h_m	m	1.5
Other Margins and Gains			
Cell edge location probability	P_L	%	90
Shadow fading variance	σ^2	dB	36
Body loss	L_b	dB	2
Building penetration loss	L_p	dB	8

a) Find the maximum allowable path loss (MAPL). [15 marks]

b) Use the COST231-Hata model (refer to Table A.3 in the Appendix) to determine the cell range for the suburban environment.

[5 marks]

c) Briefly explain how the load on the network will impact the uplink coverage of a WCDMA network.

[2 marks]

Continued...

d) State TRUE or FALSE for each of the statements below about the differences between the WCDMA and LTE air interfaces:

Statement	True/False
i) Only one frequency channel is used in WCDMA while LTE uses multiple frequency channels (or subcarriers).	
ii) Users are separated by code in WCDMA while LTE uses a combined time and frequency approach for supporting multiple users.	
iii) Soft handover is supported in WCDMA while in LTE only hard handover is supported.	

[3 marks]

Question 2

a) Explain the EPS bearer concept of the QoS in LTE.

[4 marks]

b) State TRUE or FALSE for each of the statements below about the core network elements in the LTE network:

Statement	True/False
i) MME takes care of all control plane functions related to subscriber and session management.	
ii) Radio resource control and radio mobility management are performed in eNB.	
iii) PG-W is the mobility anchor point for inter-eNB handover and for inter-3GPP mobility.	
iv) Anchor point for sessions towards the external packet data networks is at the SG-W.	
v) HSS provides subscriber profile and authentication information	

[5 marks]

Continued...

c) The design targets for the uplink of an LTE cell are given in the table below:

Criteria	Target
Required cell edge throughput	512 kbps
MIMO configuration	1T2R
Required SINR (at cell edge)	-1.8 dB
Assigned number of resource blocks	10
MCS (or TBS) Index	3
Block error rate (BLER)	10%
Receiver noise figure	3 dB
G-factor (or minimum SIR)	-1 dB
Adjacent cell load	70%

i) Based on the Transport Block Size (TBS) table given in the Appendix, determine the expected data rate (in kbps) at the cell edge.

[3 marks]

ii) Find the required receiver sensitivity. (Note: power density of thermal noise is -174 dBm/Hz)

[4 marks]

iii) Suppose the system bandwidth is 20 MHz and all the users are equally scheduled with 10 physical RBs per user. The MCS indexes of the users are uniformly distributed in the range 3 to 7. Determine the total throughput of the system in terms of bits/s (assume 10% BLER).

[9 marks]

Continued...

Question 3

a) Explain the Service-Based Architecture (SBA) concept of the 5G network.

[4 marks]

b) State TRUE or FALSE for each of the statements below about the core network functions of 5G:

Statement	True/False
i) UPF acts as a gateway to connect the RAN to external networks.	
ii) SMF handles session management and establishment, allocates IP addresses to the UEs, facilitates roaming, and controls the UPF.	
iii) NSSAAF and NSSF manage registration, reachability, mobility, connection, and location services.	
iv) AMF in charge of Network Slicing.	

[4 marks]

c) Consider a 5G NR with subcarrier spacing of 60 kHz and channel bandwidth of 100 MHz. Show that the number of available resource blocks (RBs) is 135. (Hint: For channel bandwidth of 100 MHz, the required guard band is 1370 kHz)

[4 marks]

d) Give four motivations for having multiple numerologies in 5G NR.

[4 marks]

e) Briefly describe two key technologies for improving the 5G NR coverage.

[4 marks]

End of Paper

Appendix

Table A.1 Log-normal fading margin as a function of location probability at cell edge

Location probability at the cell border, %	Lognormal fade margin, dB
50	$\sigma \times 0$
60	$\sigma \times 0.25$
70	$\sigma \times 0.52$
80	$\sigma \times 0.84$
90	$\sigma \times 1.28$
91	$\sigma \times 1.34$
92	$\sigma \times 1.4$
93	$\sigma \times 1.48$
94	$\sigma \times 1.55$
95	$\sigma \times 1.64$
96	$\sigma \times 1.75$
97	$\sigma \times 1.89$
98	$\sigma \times 2.05$
99	$\sigma \times 2.33$

Table A.2 Transport block size table

I_{TBS}	N_{PRB}						
	6	10	15	25	50	75	100
0	152	256	392	680	1384	2088	2792
1	208	344	520	904	1800	2728	3624
2	256	424	648	1096	2216	3368	4584
3	328	568	872	1416	2856	4392	5736
4	408	696	1064	1800	3624	5352	7224
5	504	872	1320	2216	4392	6712	8760
6	600	1032	1544	2600	5160	7736	10296
7	712	1224	1800	3112	6200	9144	12216
8	808	1384	2088	3496	6968	10680	14112
9	936	1544	2344	4008	7992	11832	15840
10	1032	1736	2664	4392	8760	12960	17568
11	1192	2024	2984	4968	9912	15264	19848
12	1352	2280	3368	5736	11448	16992	22920
13	1544	2536	3880	6456	12960	19080	25456
14	1736	2856	4264	7224	14112	21384	28336
15	1800	3112	4584	7736	15264	22920	30576
16	1928	3240	4968	7992	16416	24496	32856
17	2152	3624	5352	9144	18336	27376	36696
18	2344	4008	5992	9912	19848	29296	39232
19	2600	4264	6456	10680	21384	32856	43816
20	2792	4584	6968	11448	22920	35160	46888
21	2984	4968	7480	12576	25456	37888	51024
22	3240	5352	7992	13536	27376	40576	55056
23	3496	5736	8504	14112	28336	43816	57336
24	3624	5992	9144	15264	30576	45352	61664
25	3752	6200	9528	15840	31704	46888	63776
26	4392	7480	11064	18336	36696	55056	75376

Table A.3 Path loss models

Model	Expression	Remarks
Free space	$PL = -27.55 + 20\,log_{10}(f) + 20\,log_{10}(d)$	f is in MHz, d is in m
Okumura-Hata	$PL = A + B\,log_{10}\,d + C$ where $A = 69.55 + 26.16\log_{10} f - 13.82\log_{10} h_b - a(h_m)$ $B = (44.9 - 6.55\log_{10} h_b)$ Small and medium-size cities (urban) $a(h_m) = (1.1\log_{10}(f) - 0.7)\,h_m - (1.56\log_{10}(f) - 0.8)$ $C = 0$ Metropolitan areas $a(h_m) = \begin{cases} 8.29(\log_{10}(1.54h_m))^2 - 1.1 & f \le 200MHz \\ 3.2(\log_{10}(11.75h_m))^2 - 4.97 & f \ge 400MHz \end{cases}$ $C = 0$ Suburban environments $a(h_m) = (1.1\log_{10}(f) - 0.7)\,h_m - (1.56\log_{10}(f) - 0.8)$ $C = -2[\log_{10}(f/28)]^2 - 5.4$ Rural area $a(h_m) = (1.1\log_{10}(f) - 0.7)\,h_m - (1.56\log_{10}(f) - 0.8)$ $C = -4.78[\log_{10}(f)]^2 + 18.33\log_{10}(f) - 40.98$	f is in MHz, d is in km, and antenna heights are in m
COST 231-Hata	$PL = A + B\log_{10}\,d + C$ where $A = 46.3 + 33.9\log_{10} f - 13.82\log_{10} h_b - a(h_m)$ $B = (44.9 - 6.55\log_{10} h_b)$ $a(h_m) = (1.1\log_{10}(f) - 0.7)\,h_m - (1.56\log_{10}(f) - 0.8)$ C = 0 dB in dense urban; -5 dB in urban; -10 dB in suburban; -17 dB in rural	f is in MHz, d is in km, and antenna heights are in m